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THE EARLY STAGES OF VARIOUS SPECIES OF THE GENUS *DIRPHIA* (SATURNIIDAE)

BRIAN O. C. GARDINER

18, Chesterton Hall Crescent, Cambridge, England.

INTRODUCTION

THIS PAPER IS ONE OF A SERIES describing the rearing in England of various Neotropical Saturniidae and deals with five species of *Dirphia*, as defined by Michener (1952). Eggs were sent to me by airmail; *D. avia* Stoll from Trinidad by Dr. A. D. Blest; *D. baroma* Schaus, *D. curitiba* Draudt, *D. lombardi* Bouvier, and *D. ursina* Walker, from St. Catarina, Brazil, by Sr. Fritz Plaumann. The first three of these were successfully reared through to adults, but the larvae of the last two died after several instars. The various stages were kept at 20-25°C., with occasional fluctuations of $\pm 5^{\circ}\text{C}$. and under natural daylight conditions, but with additional light during the evenings while the stocks were being attended to. The duration of the various stages is summarized in Table 1.

DIRPHIA AVIA

From 375 eggs received 23.VI.61, a total of 205 healthy and 8 deformed pupae were obtained. In addition about 25 larvae were preserved.

The eggs—Laid in rather irregular batches. Shiny white with a small black micropyle. Virtually spherical 2.5 mm diameter. There is no prior indication before the larva hatches.

The larvae—In the 1st instar black with a dark brown head. Chalazae black, forked like a Y on the first 3 segments, simple, but a distinct bend two thirds of the way up, on the remainder. In the 2nd instar they become greyish dorsally, reddish-brown ventrally. In the 3rd instar the ground color a dirty white with black markings, these now persisting to the final stage, the ventral surface becoming less reddish and more like the dorsal as growth progresses.

The fullgrown larvae 8-10 cms long (the females being the larger). Ground color, including the head, a light grey with a tinge of green or violet, the color depending rather on how the larva is being viewed and the incident light. On each segment black markings, variable in both number and extent, the most prominent being a dorsal mark like a broad arrow () facing backwards and situated on each segment between the chalazae. The spiracles white, outlined in black. The chalazae grey; the spires grey with black tips; both have a violet sheen to them. The armature firm and fairly formidable. The thoracic chalazae and spines particularly long, overhanging and protecting the head. The prolegs with black crochets. The head grey with a broad inverted V above the brown mouthparts.

Larval habits—The larvae are gregarious throughout their life and wander about in long processional columns. They feed by night and rest by day in a dense communal cluster. This was usually formed at the base of the foodplant which in this case consisted of a polythene water bottle containing the branches on which the larvae were being fed. So determined were the larvae to walk down the stalks that unless the neck of the bottle was extremely tightly plugged with Kleenex tissue, several of the larvae would drown themselves. When they are disturbed the larvae cling tight; they neither drop nor assume any unusual attitude, except that the head is slightly retracted and the thoracic spines lowered around it.

Sting—From the second to fourth instar the sting from the spines is about equivalent to that from a nettle (*Urtica dioica*), or a fullgrown *Automeris io* Fabricius. That of the fullgrown larva however is far more severe, as painful as that of wasps (*Vespa vulgaris* Linnaeus; *V. germanica* Fabricius), but shows only the usual type of Histamine reaction (Jones & Miller, 1954) bleb which soon wears off although the area is a little tender for a few days.

Pupation—This species was the first of the Neotropical Hemi-leucinae to be bred by the author and their unusual habits and individual idiosyncrasies were still strange to him. The finding of the correct foodplants and the optimum conditions for pupation were as yet unknown. The *D. avia* were therefore given a standard choice by being given a layer of peat overlain with moss in their rearing cage. This gives all the conditions required by species that pupate (a) in rolled leaves; (b) in litter; (c) underground. This species proved to be one of the few per cent

that is not satisfied with any of these three usual alternatives and demand specialized treatment.

When they are ready for pupation the larvae turn a purplish-red color which gradually darkens as they restlessly hunt for a suitable site over two or three nights. However, once the cocoon has been spun, the pre-pupa assumes the original larval color except for the spines, these remaining purple.

In their cages they wandered endlessly around, but during the day took their place in the communal resting cluster. Only about a dozen actually spun cocoons in the cages and over half of these failed to form normal pupae. Seeing that they were so obviously unhappy in the cages the larvae were removed and placed either singly in $\frac{1}{2}$ lb. tins or in pairs in 2 lb. tins. These tins contained a wad of sphagnum moss on top of a few inches of moist peat. They were fitted with tight metal lids and were used on the theory that the larvae were seeking somewhere totally dark. Be that as it may, all the larvae put into the tins pupated successfully. They formed a large flimsy papery cocoon between the peat and the moss, often attached to the side of the tin.

It is certain that in nature these larvae choose some specialized site; it is not unlikely that this is inside some species of Epiphyte.

Foodplants—The larvae were reasonably polyphytophagous on various temperate deciduous trees and one evergreen tree. The following were accepted: Hawthorn (*Crataegus oxyacanthae*); Beech (*Fagus sylvatica*); Plums, Cherries (*Prunus* spp.) Oaks (*Quercus* spp.—including *ilex*); Apple (*Malus* sp.). Black poplar (*Populus nigra*) and Privet (*Ligustrum ovalifolium*) were refused. Very freshly shooted Willow (*Salix* sp.) was eaten for the first two days by the newly hatched F1. larvae, but they so readily switched over to Evergreen oak (*Q. ilex*) that Willow was not considered really suitable. For the sake of convenience the larvae were mainly reared on Hawthorn and Beech, the F1 on Evergreen oak.

Adults—The majority of the pupae were disposed of and only a few kept for adult emergence. Two pairs were obtained, both of females that were three days old and had already laid a considerable number of eggs. Both these pairs were obtained when the temperature had been raised from 22°C to 30°C over some four hours and then dropped over one hour to 25°C. Several other moths placed together failed to pair. It is not

clear if the temperature fluctuation was of any significance or not. The two pairs occurred some five hours after sunset, the moths remained in copula for at least 90 minutes, had separated by morning.

From these two females a few small egg-batches were laid, in both cases laying only took place over about the 3 hours after dusk. About 75 per cent of the eggs hatched.

The adults lived for about 7 days. Females commenced to 'call' the same day as they emerged. Females started to lay infertile eggs in irregular masses if not paired after two or three nights, although even after this they would spend a short time calling each night. Males soon battered their wings to pieces after which they flapped rather helplessly on the cage floor.

DIRPHIA BAROMA

Eggs of this species were in a packet that arrived 29.VIII.63 after being a month in transit from Brazil. There had been some shaking up and these eggs were mixed with those of *D. curitiba*. They had just hatched on arrival. All five were reared.

Eggs—The remains of the eggshells were indistinguishable from those of *D. curitiba* (see below).

The larvae—In the 1st instar body dark reddish-brown. Head shiny black. Chalazae off-white, blackish towards tips. No records were kept of intermediate instars, but by the third the larva had assumed the general pattern of the final. The final instar larva 8 cms long. The head and anal segments black. Ground color, ventral and dorsal, black, with a brick-red incomplete band on each segment laterally and dorsally. Legs black with red spots. Chalazae and spines pale blue. The chalazae short, the spines arising starlike fairly long. Rather uniform and regular on each segment. This arrangement in fact resembles that of *Automeris memusae* Walker or *A. nyctimene* Latreille.

Larval habits—Since there were only five specimens the larvae were kept throughout in a plastic box. Apart from the fact that they kept bunched together and fed by night, the sample was too small to give any clear indication of habits.

Sting—This was not experienced.

Pupation—When ready to pupate the colors faded. The larvae were removed to tins with moss and peat. They pupated underground in the peat, forming a cocoon similar to that of a Sphingiid.

Foodplants—The newly hatched larvae were offered Beech, Hawthorn and Laburnum (*Laburnum anagyroides*) on which they commenced to feed, but after a week they transferred to Beech. The final instar finished their development on Evergreen oak. The following were refused: Privet; Plum; Elm (*Ulmus campestris*).

Adults—After nearly three months all the pupae produced adults within a week. Unfortunately all five were females.

DIRPHIA CURITIBA

Eggs of this species were received in 1962 and again in 1963. Those of the first year were reared with virtually no larval mortality, but from the second year there was a high larval mortality from what appeared to be granulosis virus disease. This disease caused the gradual and total loss of the F1. larvae. The information below is based on the first lot received 29.IX.62, which were a month in transit.

Eggs—Shaped like a slightly flattened ovoid, color white with a large black micropyle. Laid in regular groups of several dozen eggs, fastened strongly to the substratum with a clear cement. It was noticed that infertile eggs were encircled by a wide grey band on the upper half. No prior indication to larval hatch. Eggshells partly consumed by the newly hatched larvae.

The larvae—In the first instar brownish, including spines, head black. Second instar similar. In subsequent instars greenish-grey with black markings. The fullgrown larva 7.5 to 10.0 cms long (the females doubtless being the larger). Dorsally the ground color greenish-grey, or brownish, ventrally whitish-grey. The whole body covered with an intricate series of black markings which vary very considerably between larvae, in some coalescing to form large blotches which run continuously from one segment to the next. The spiracles are white, lightly outlined in black. The whole larva densely covered with spined chalazae. These particularly large and dense on the thoracic segments, and the anal, being here at least 1.5 cms long, projecting over the head and to the rear, as in *avia*.

Larval habits—Similar to *avia*.

Sting—Similar to that of *avia*.

Pupation—Also similar to *avia* and it was necessary to remove the larvae individually to tins. They also turn purple when ready for pupation. The cocoon appeared to be a little flimsier than that of *avia*.

Foodplants—Having been informed by Sr. Plaumann that they fed on Juglandaceae, especially Walnut (*Juglandia regia*) this was offered, together with Plum and Laburnum. They commenced to feed on the Walnut two days after hatching but by the fourth instar the supply failed. Oak and Peach (*Prunus persica*) were offered and accepted. Holly (*Ilex* sp.); Privet and Laurel (*P. lusitanica*) were refused. Their development was completed on Evergreen oak.

In the F1 generation the newly hatched larvae refused to start feeding on Walnut. This had been forced and it might well be the the very fresh soft leaf is unsuitable in some way. The parents had of course been given late fall leaves. These F1 larvae, with about 20 per cent loss, eventually started feeding on Oak, but after two weeks all the larvae accepted Beech and completed their development on this. The F3 generation was fed entirely on Evergreen oak.

The newly arrived larvae in 1963 were given a choice of Walnut and Beech. All preferred the Beech. The F1 generation of these was offered and fed on Hawthorn (other leaf being unavailable). As already stated however all these died of what appeared to be virus disease.

Adults—These behaved in much the same way as *avia*. Probably because rather more were available pairing proved relatively easy, without the temperature fluctuation which occurred before the *avia* pairing. Pairing took place some 2-3 hours after dusk and lasted 1-2 hours although two to three pairs were still coupled the following morning. Not all the pairings produced fertile eggs. Females either laying fully fertile, totally infertile, or mixed batches. The females that laid totally infertile batches behaved as if they were laying fertile eggs. That is, they laid in regular batches. Virgins, after several nights 'calling' would lay in a jumbled pile. It seems as if the correct laying reaction is initiated by the act of coupling, not fertilization. In the conditions of captivity 100-150 eggs per female were laid. This is by no means their full potential, on estimate, less than half. Only 1 pairing was obtained of the F2 generation. Two pairings were obtained from the F3 but no viable eggs were laid. By now of course the stock was brothers and sisters already one generation inbred, so this is perhaps not surprising.

DIRPHIA LOMBARDI

Eggs of this species were received 29.IX.62 and were just hatching on arrival after a month in transit. Sr. Plaumann gave Lauraceae? as possible food. All the larvae died by the end of the fourth instar.

Eggs—As received these were laid in a jumbled pile. The color white with a black micropyle. In shape, a slightly flattened ovoid, 1.75 mm x 1.5 mm x 2.0 mm high.

The larvae—In the first instar the dorsal surface rather blackish, a dirty white ventrally and laterally. Head black. After feeding and growing a little the larvae become overall whitish with black spines. In the 3rd instar a green lateral stripe has appeared, ground color now greyish-brown. The ultimate death of the larvae appeared to be due to granulosis virus disease.

Larval habits—Processionary and gregarious in the first three instars.

Sting—Not experienced.

Pupation—None were pupated.

Foodplants—The newly hatched larvae were offered a choice of Black locust (*Robinia pseudo-acacia*), Plum and Beech. They commenced to feed on Plum on which they were kept throughout their life. Evergreen oak, and Laburnum which were offered in the 3rd instar were refused.

DIRPHIA URSINA

Eggs of this species were received 29.IX.62 and again on 22.X.64. None of the larvae survived beyond the end of the fourth instar. The first batch apparently died of granulosis virus disease. The second batch almost certainly died due to the failure to find a suitable food for them; due to their rather late fall arrival the plum known to be suitable had already nearly fallen and the unsuccessful attempts to find a suitable alterantive led to starvation and resultant debility in the first instar. None survived beyond the second.

Eggs—As received these were laid in a jumbled pile. The color off-white with a black micropyle. Almost spherical and about 2.0 mm in diameter.

The larvae—The newly hatched larvae are purplish in color, including the spines and chalazae, with a black head. There was a steady mortality of the 50 or so larvae that commenced to feed. The three that reached the fourth instar had hardly changed in appearance from the first.

Larval habits—Processionary and gregarious in the first few instars.

Sting—Not experienced.

Pupation—None were pupated.

Foodplants—The newly hatched larvae were offered a choice of Black locust or Plum. The latter was accepted. Accompanying the second batch was a note from Sr. Plaumann that they fed on Wistaria (*Glyzine*). In late October in England the only Wistaria leaves available were in an advanced state of senescence; once picked they dried up overnight, even when kept in a high humidity. There were, not unexpectedly, refused by the larvae which again accepted Plum. Decent green leaves of this too, were hard to find. Laburnum, Everlasting pea (*Lathyrus latifolius*) and Laurel were offered but refused.

DISCUSSION

I have been informed (Blest, *in lit.*) and by others who have had tropical experience, that many Tropical Lepidoptera, including specifically *Dirphia* and *Automeris* species are extremely difficult to rear where they occur. Either they refuse to accept any available foodplant offered, or they prove to have been attacked by parasites, or die of virus diseases. Larvae collected wild in the forest have been known to refuse to accept the leaves of an apparently identical tree to that on which they were found. Also it is not very easy to collect foodplant from the canopy of a tropical forest.

When translated to a temperate zone, natural parasites, but not inheritable virus diseases are eliminated. So too of course, are the natural foodplants. Since in the majority of cases these are unknown, it becomes a question of trying one tree after another until one that is acceptable to the larvae is offered. Once they have commenced to feed, other leaf may be offered later, either because it is more readily available, or simply to find out what range of plants are acceptable. In the case of these *Dirphia* the larvae of three species proved to be reasonably polyphytophagous on temperate zone deciduous trees. The other two, *ursina* and *lombardi* only accepted one, Plum, but the larvae only having been available late in the year, other leaf, acceptable to the first three, was not available. It is perhaps significant, however, that Evergreen oak was refused. Without this the first three species could not have been reared. It would appear that *ursina* and *lombardi* have a different food range to *avia*, *baroma* and *curitiba*.

The larvae of *ursina* and *lombardi* having died in the early stages, it is difficult to make a comparison between them and the other three. Nevertheless their general appearance and the arrangement of the chalazae and spines were similar to those of *avia* and *curitiba* in similar instars. The odd one out is *baroma* which as already mentioned, has a structure similar to that of certain *Automeris* larvae. Its mode of pupation is also unusual being dissimilar to that of any other *Dirphia* moth known to me, but similar to that of *Eudyaria venata* Butler (Crotch, 1956).

Little appears to be known about the life-cycles, but I have not carried out an exhaustive search of the literature. This would be no easy matter, as much of the literature likely to carry information concerning *Dirphia* (i.e., local South American journals) is not very readily available. Before and during this investigation some two dozen enquiries were made of various institutions and colleagues in the Neotropical area. None was able to give me any information.

In the conditions of captivity there was a life-cycle, in the three species reared to adults, of six months and two generations a year could be obtained. It is difficult to obtain precise information on the occurrence and number of broods of many tropical species, but it does appear that these *Dirphia* are normally single-brooded. The related *D. jörgenseni* Schaus (Schreiter, 1943) is single-brooded in Northern Argentina and my supplier in Southern Brazil, Sr. Plaumann, tells me that *curitiba* and other species are single-brooded. This data quite clearly shows that these species therefore, have a facultative light-controlled diapause, but the exact determining conditions were not clearly defined by the present investigation.

According to Crotch (1956) *Dirphia* larvae are said to be long, cylindrical, with long slender single spines emerging directly from the body; at least one species is thought to have large lappets; a few species appear to spin cocoons not unlike *Saturnia pyri* Schiffermüller. None of these statements is true of the five species described in this paper. It is true that *Dirphioptis eumedide* Stoll has two small paired 'lappets' (Gardiner, 1966), but these are neither large, nor in the position assumed. This species was included in *Dirphia* by Draudt (1930).

The following larvae, of which I have traced a published description, bear a structural similarity to *avia* and *curitiba*. *Eudyaria venata* Butler (Burmeister, 1879, as *Dirphia consularis*

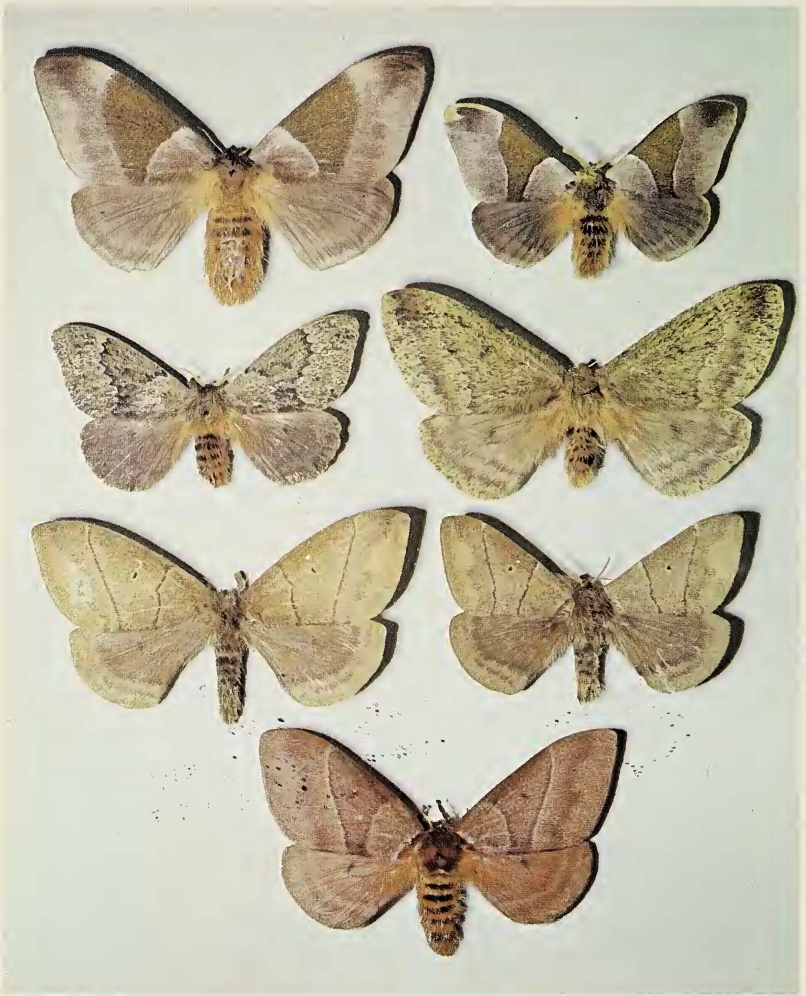


Fig. 1.—*Dirphia* imagines. Top, *avia*; second row, *curitiba*; third row, *ursina*; bottom, *baroma*, female only.



Fig. 2.—Larva of *Dirphia avia*.



Fig. 3.—Larva of *Dirphia curitiba*.



Fig. 4.—Larva of *Dirphia lombardi*.

Burmeister); *Molippa sabina* Walker and *M. simillima* D.-Jones (D.-Jones, 1907). *D. jörgenseni* Schaus, however, (Schreiter, 1943) bears a remarkable resemblance to *baroma*, but pupates amongst the foodplant, not underground.

The question arises as to whether the present work on the larvae has any bearing on the confused issue of the classification of *Dirphia* and its relatives.

Draudt in Seitz (1930) divided the genus *Dirphia* into ten groups. This grouping was largely re-distributed by Michener (1952), some species being removed by him to separate genera, other genera of Draudt being brought into the *Dirphia* orbit. Although Michener uses a system of subgenera, I prefer, taking into account the larval characteristics and pupation habits, to regard his subgenera as separate genera. It is impossible from larval characters as at present known, to regard *Periphoba hircia* (see Gardiner, 1967) as being at all closely allied to for instance *Dirphiopsis eumedide* (see Gardiner, 1966) and *Dirphia baroma*, or the latter two to each other. *Dirphiopsis eumedide* shows similarities to *Dirphia jörgenseni* and they should perhaps be placed in the same genus but not *Dirphia*. On the other hand *E. venata* bears such a striking resemblance to *avia* or *curitiba* that it should be transferred back into *Dirphia*.

The larvae of *lombardi* and *ursina* at the time of their death in the fourth instar clearly resembled contemporary larvae of *avia* or *curitiba* and it is therefore considered that they too belong in *Dirphia*.

ACKNOWLEDGMENTS

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Fig. 5.—Larva of *Dirphia baroma*.

TABLE I

The duration in days of the various stages in the life-cycle
of the *Dirphia* species

Species	Egg								Mean Total	Pupa
		1	2	3	4	5	6	7		
avia	30	8	8	7	4	4	8	25-37	70	62
baroma	34	9	10	7	12	10	13	0	61	82
curitiba	32	9	7	7	8	12	30-45	0	81	105
lombardi	31	7	7	10	-	-	-	-	-	-
ursina	31	6	11	11	-	-	-	-	-	-

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VOLTINISM AND HOST SPECIALIZATION

Opler and Buckett (1971), working with the large macro-moth fauna of Santa Clara County, California, suggest that the breadth of host specialization is correlated with voltinism; specifically, that univoltine species tend to be monophagous and multivoltines polyphagous. This correlation, if valid, suggests a primary biological basis for the adaptiveness of univoltinism: synchronization with a host plant which is seasonally limited in availability. Individual examples of such life cycles are well-known in North American butterflies. In some cases (e.g. *Pieris virginiensis* Edwards on *Dentaria*) the host plant is an ephemeral vernal species, annual or perennial. In others the edible part of the host is available only at certain seasons, even though the plant itself is present most or all of the year. This seems to be true of the insect faunas of tannin-rich plants. Tannins interfere with protein uptake, and the foliage of such plants is nutritionally useful only in spring before much tannin has accumulated (first demonstrated for the Geometrid *Operophtera* on oak by Feeny, 1970; probably applicable to *Satyrrium*, *Erynnis*, etc.). Burns (1964) notes that the multivoltine *Erynnis tristis* oviposits and feeds on the young growth on evergreen oaks and avoids the older leaves. Such growth is limited in quantity and might be expected to be the object of intense competition among oak-feeding insects so long as the disadvantages of competition do not outweigh the advantages of rearing more than one brood a year.

Fair to good host plant data are at hand for 37 species of butterflies in the Sacramento Valley. These may be put into three categories of host specialization: monophagous, defined as restricted to a single plant genus in the geographical area in question; oligophagous, restricted to two or more genera in the same plant family; and polyphagous, feeding on two or more plant families. In the Valley all of the univoltine species are monophagous (Table 6), while just over two-thirds of the multivoltines are oligo- or polyphagous. Oligophagy is the commonest pattern: only three multivoltines (*Vanessa cardui*, *Plebeius acmon*, and *Papilio rutulus*) are polyphagous. Two of these are clearly colonizers. Most multivoltines have to change hosts during the season, but for many (*Pieris* on Crucifers, *Colias eurytheme* and *Everes comyntas* on Legumes) a seasonal succession of wild hosts of one family is available even in the absence of agriculture.

These data thus tend to bear out Opler and Buckett's suggestion. Univoltinism may result from other selection pressures besides host phenology, of course; perhaps it is better to say that both host specialization and voltinism are apt to be related to interspecific competition. Differences in phenology in different parts of the ranges of species may offer clues to selective factors acting on the timing of life history phenomena. *Lerodea eufala*, for example, is found only from June to early winter in both northern and southern California (Emmel and Emmel, 1973). Yet in the southeastern United States it flies all year, being recorded as early as ii.9 in coastal Georgia (Harris, 1972). *Brephidium exilis* flies nearly all year in southern California, but not before June in the Valley or at Suisun Bay; Opler and Langston (1968) record it as early as April in Contra Costa County, as does Tilden (1965a) for the San Francisco Bay area. In this case, however, it is not certain that *B. exilis* overwinters successfully inland at the latitude of Sacramento.

THE VALLEY AS A FAUNAL BARRIER

The Sacramento Valley is about 35 miles wide at the latitude of Davis. Across this expanse of flat land the habitats and plants of the foothills are absent, and many characteristic foothill butterflies (such as *Papilio eurymedon* Lucas, *Chlosyne palla* Boisduval, *Satyrium saepium* Boisduval, *Lycaena gorgon* Boisduval, *Callophrys dumetorum* Boisduval, *Thorybes pylades* Scudder) disappear as well. The data on the pristine vegetation of the Valley (Thompson, 1961) suggest that this barrier may have been much less dramatic in pre-American times. A few isolated pockets of foothill vegetation still exist in the Valley (e.g. Buckeye, *Aesculus californica* (Spach) Nutt., and Pipevine, *Aristolochia californica* Torr. on the north fork of Putah Creek near Barthel's Ranch, southeast of Davis). Along the intermittent streams such plants must have come down some distance below the mouths of the canyons, and they may have formed an element of the riparian forest on the permanent streams. Because of changes in the habitats, it is at present impossible to evaluate the historical role of the Valley as a barrier to dispersal between the Sierras and coast ranges. The butterfly faunas at comparable elevations are strongly similar across it, though at least three species (*Satyrium saepium*, *S. auretteorum*, *Chlosyne palla*) are phenotypically distinguishable in the two ranges. At least one species, *Poanes melane*, was apparently continuously distributed across the Valley in riparian habitats but is now restricted to the two systems of foothills and the major riparian habitats

around Sacramento; it occurred at Davis (Willowbank?) as late as 1947 (Heppner, 1973). The present distribution of *Glauco-psyche lygdamus behrii* is very similar.

Eight or nine species of foothill butterflies enter the Valley more or less regularly but do not breed there. *Nymphalis californica* migrates regularly across the Valley floor (Shapiro, 1973); *Limenitis bredowii californica*, another strong flyer, is frequently seen at Davis. It is very unlikely that either of these species ever breeds in the Valley. In contrast, two relatively weak-flying Lycaenids, *Incisalia iroides* and *Lycaenopsis argiolus echo*, enter the Valley along the streams and have been recorded so often that both are suspected of breeding, although no known hosts are available.

A valid study of the effectiveness of the Valley as a barrier to faunal exchange must await a survey of the isolated Sutter Buttes in the mid-north Valley, planned for the next two seasons.

ENDEMISM AND EXTINCTION

The Willow Slough population of *Phyciodes campestris* is the most distinctive Valley endemic. Valley populations of *Everes comyntas* and *Limenitis lorquini* are phenotypically weakly distinguished, and *Satyrium californica* has an unusual host (*Quercus lobata*). On the whole, however, the Valley fauna is strikingly lacking in endemic populations; it is composed largely of wide-ranging, vagile species with little tendency toward geographic variation.

It seems inevitable that more distinctive butterflies must have existed in the pristine Valley, with its well-developed plant communities of considerable antiquity. The Hesperidae in particular are lacking in the modern fauna; there is no Valley *Hesperia* of any kind, for example. It is conceivable that relict populations of undescribed Valley endemics may still exist in isolated or unexplored areas which have escaped intensive modification by man. The recent discovery of *Ochlodes yuma* in southern Sacramento County indicates that the list of Valley butterflies may not yet be complete. It is unlikely, however, that we will ever be able to reconstruct—or even guess intelligently—the composition of the pre-American Valley fauna.

FAUNAL LIST

Host plants are based on actual oviposition or larval records in the Sacramento Valley only. Botanical nomenclature is from

Munz (1970). Butterfly nomenclature is mostly as in Ehrlich and Ehrlich (1961) and skippers mostly as in dos Passos (1964). All records are for Yolo, Solano, and Sacramento Counties only. Flight periods for the 1972 and 1973 seasons are given in Tables 7 and 8 on a weekly basis.

Family Danaidae

1. *Danaus plexippus* Linnaeus. Monarch.

Common throughout. Four broods in both 1972 and 1973. Open country, especially along sloughs, ditches, and railroads with the host plants. No overwintering occurs in the Valley. The spring immigration from the west is more conspicuous than the autumn emigration. Tagged specimens recovered in the Valley and the Vacas indicate that at least some of our population overwinters in Marin County. *Host Plants: Asclepiadaceae; Asclepias fascicularis* Dcne.

Family Satyridae

2. *Coenonympha tullia californica* Westwood and Hewitson. California Ringlet.

Frequent but spotty, usually found in the Sacramento and American River floodplains, but not restricted to them. Throughout the season, as in the foothills; probably two broods, the second very protracted. Although breeding has not been confirmed in the Valley, this species is very probably resident. Generally absent from the heaviest clay soil areas.

Family Heliconiidae

3. *Agraulis vanillae* Linnaeus. Gulf Fritillary.

A rare stray. Since this species bred in the San Francisco Bay area in the 1960s it is perhaps capable of colonizing the Valley, at least temporarily. The normal hosts, Passifloraceae: *Passiflora* spp., are occasionally cultivated but there are no native species here.

Family Nymphalidae

4. *Speyeria callippe* Boisduval. Callippe Fritillary.

A rare stray; one male, fresh, v.9.72, northwest Davis. It is not known what subspecies or source area this individual represents. (Note: *Speyeria coronis* Behr has been taken at Suisun Bay (ix.23.72) and could stray into the Valley on the west side.)

5. *Euphydryas chalcedona* Doubleday and Hewitson. Common Checkerspot.

Occasional in floodplains, as at the American River and Putah Creek, probably as a stray from the foothills where it is abundant. No larvae have been collected in the Valley, where the usual host, Scrophulariaceae: *Diplacus*, does not occur.

6. *Chlosyne lacinia crocale* Edwards. Bordered Patch.

This species was not seen in 1972, but in 1973 about 15 were taken on the American River floodplain at Camp Pollock. These included all three color forms illustrated by Emmel and Emmel (1973). There were at least two broods. The Bordered Patch is indigenous to southeastern California, in the Imperial Valley and Colorado Desert, and seems to be unreported even as a stray anywhere north of the Transverse Ranges. Its future history in the Valley should be very interesting. *Host Plant:* The usual host, Compositae: *Helianthus annuus* L., is abundant on the floodplain.

7. *Phyciodes campestris* Behr. Field Crescent.

Very local. The Sacramento Valley populations differ from others seen in the smaller size and heavier infuscation dorsally (illustrated in Shapiro, 1974b). There is a large, vigorous colony along Willow Slough from northwest of Davis to the Yolo Bypass, and smaller colonies at north Woodland, Stone Lake-Beach Lake, and North Sacramento; strays to Davis, Willowbank, West Sacramento, mainly in autumn. Three broods. To be sought in

sandy bottomlands with good stands of the host. *Host Plant*: Compositae: *Aster chilensis* Nees. I took a female investigating *Aster novi-belgii* L., an eastern species, in a garden at Davis.

8. *Phyciodes mylitta* Edwards. Mylitta Crescent.

Common everywhere; four broods. Larva overwinters, feeding up in February-early March. *Host Plants*: Compositae: *Silybum marianum* (L.) Gaertn.; *Cirsium californicum* Gray; *C. vulgare* (Savi) Tenore; *Carduus pycnocephalus* L. *Centaurea solstitialis* L. is suspected.

9. *Polygonia satyrus* Edwards. Satyr Anglewing.

Uncommon, recorded mostly as singletons. Riparian forest (Southport, Sacramento River; Northgate, Sacramento State University area, both American River); once in Davis. Not confirmed to breed in the Valley, but the usual host, Urticaceae: *Urtica*, is common in the places where it has been found.

10. *Nymphalis californica* Boisduval. California Tortoiseshell.

Frequent as a transient in spring and fall, but not known to breed in the Valley where its usual hosts Rhamnaceae: *Ceanothus* do not occur. Completely absent during the hottest weather, and not appearing in spring until several weeks after it begins flying in numbers in the Vacas. In 1972 a significant west-to-east migration across the Valley occurred, beginning about v.26; in 1973 the same phenomenon occurred vi.8-11. The return, east-to-west movement was noticeable in Davis on x.1-x.3.73. (Note: *Nymphalis milberti* Latreille was taken at about 1000 feet in the Spenceville Recreation Area, Yuba Co., iv.11.73, and may reach the Valley floor on occasion northward.)

11. *Nymphalis antiopa* Linnaeus. Mourning Cloak.

Frequent to common in bottomlands and riparian forest; occasional elsewhere. Apparently one brood, becoming dormant by August and not flying again until February. Larvae colonial and often locally conspicuous. *Host Plants*: Salicaceae: *Salix lasiandra* Benth.; not seen on *S. hindsiana* Benth., the commonest willow in the Valley, but reportedly damaging *S. Babylonica* L. in gardens in Sacramento. The seeming avoidance of *S. hindsiana* may reflect its being widely utilized by larvae of the diurnal Saturniid *Pseudohazis eglanterina nuttalli* Strecker at the same time.

12. *Vanessa atalanta* Linnaeus. Red Admiral.

Common in the Sacramento-American River floodplains, and frequent throughout. Probably three broods. *Host Plants*: Urticaceae: *Urtica holosericea* Nutt., a common understory plant of riparian forest and thickets, absent in other habitats; also *Soleirolia* (*Helxine*) *soleirolii* (Baby's Tears), an introduced Urticaceous ground cover, in Davis.

13. *Vanessa* (*Cynthia*) *virginiensis* Drury. Painted Beauty.

Frequent in riparian forest, forest edges and nearby roadsides; rare elsewhere; the least common *Vanessa*, seldom seen before midsummer. Apparently four broods. *Host Plants*: Compositae: *Gnaphalium palustre* Nutt. (at Southport), probably other *Gnaphalium*.

14. *Vanessa* (*Cynthia*) *cardui* Linnaeus. Painted Lady.

Common and general. Immigrant, rearing three broods in 1972. 1973 was an outstanding year for this species, which flew for 44 weeks and bred in great numbers. Its migrations and variation are described in Shapiro (1974c). *Host Plants*: Extremely polyphagous, though in normal years mostly restricted to the plants marked *. Compositae: *Silybum marianum* (L.) Gaertn.*; *Cynara scolymus* L. (artichoke); *Carduus pycnocephalus* L.*; *Cirsium vulgare* (Savi) Tenore*; *Xanthium strumarium* L. var. *canadense* (Mill.) T. & G. (West Sacramento, v.26.73, larvae); *Centaurea solstitialis* L.; *Helianthus annuus* L. (Davis, vii.6.73, larvae common); *Wyethia glabra* Gray; Leguminosae: *Lupinus bicolor* Lindl. (oviposition near Winters, iii.18.72); Boraginaceae: *Amsinckia douglasiana* A. DC.*; Malvaceae: *Malva parviflora* L.*, *M. neglecta* Wallr.*; *M. nicaeensis* All.*; *Althaea rosea* L.; *Sida hederacea* (Dougl.) Torr. (larvae all season, Davis, 1973); Urticaceae: *Urtica urens* L. (Woodland Sinks, larva, v.13.73); Plantaginaceae:

Plantago lanceolata L. (Putah Creek, v.16.73, 3 larvae); Hydrophyllaceae: *Eriodictyon californicum* (H. & A.) Torr. (Putah Creek, vi.15.73; also seen in Amador Co.).

15. *Vanessa (Cynthia) annabella* Field. West Coast Lady.

Abundant, general, flying all year. Five to six broods. For figures and discussion of variation see Shapiro, 1974d. *Host Plants*: Malvaceae: *Malva parviflora* L., *neglecta* Wallr., and *nicaeensis* All.; *Althaea rosea* L.; *Sida hederacea* (Dougl.) Torr. (rarely).

16. *Precis coenia* Hubner. Buckeye.

Common to abundant in bottomlands and on sandy soils; frequent to common elsewhere. Restricted to bottomlands early in the season, but generally distributed by late vi. It is not certain that *P. coenia* overwinters in the Valley at all. It is abundant in foothill canyons (where it feeds on Scrophulariaceae, especially *Diplacus*) 3-6 weeks before it appears on the Valley floor. After late viii specimens, especially females, are very red or purplish beneath; but some clay-colored butterflies reappear after mid xi and until hard frost. The February butterflies in the canyons are clay-colored and undersized, and seem to be a mixture of fresh and worn individuals. *Host Plants*: Verbenaceae: *Lippia lanceolata* Michx. and (in cultivation) *L. nodiflora* Michx. vars. *canescens* (HBK.) Kuntze and *rosea* (D. Don) Munz; Plantaginaceae: *Plantago lanceolata* L. (at Vacaville, in lawns). Tilden's speculation (Tilden, 1971) that true *P. coenia* does not feed on *Lippia* is clearly in error; more than 100 wild larvae were collected from this plant at Davis and reared in 1973, and larvae have also been found on it at Fairfield.

17. *Limenitis lorquini* Boisduval. Lorquin's Admiral.

Common in riparian forest and among young willows along creeks, sloughs, and levees; very rare elsewhere, once seen on the University of California campus at Davis. Three broods. Valley specimens are, on the average, less orange and more bluish beneath than foothill ones. *Host Plant*: Salicaceae: *Salix lasiandra* Benth.; not seen on *S. hindsiana* Benth.

18. *Limenitis bredowii californica* Butier. California Sister.

Infrequent and sporadic. Not known to breed in the Valley, although acceptable oaks are locally available especially near the foothills. Probably formerly resident when the oak-Buckeye association extended farther down the streams.

Family Lycaenidae

19. *Atlides halesus* Hubner. Great Blue Hairstreak.

Common in riparian forest; frequent to common in residential neighborhoods with established deciduous trees; rare elsewhere. Three (perhaps a rudimentary fourth) broods. *Host Plant*: Loranthaceae: *Phoradendron flavescens* (Pursh.) Nutt. var. *macrophyllum* Engelm., typically on Cottonwood along the rivers, on various other deciduous trees elsewhere.

20. *Strymon melinus pudica* Henry Edwards. Common Hairstreak.

Abundant throughout, breeding continuously; about five broods. A few specimens lack the postmedian line and shading on the forewing ventrally. One female with the orange completely replaced by white, Davis, vi.3.73. *Host Plants*: Malvaceae: *Malva nicaeensis* All. and *neglecta* Wallr.; *Sida hederacea* (Dougl.) Torr. (preferred). Euphorbiaceae: *Eremocarpus setigerus* (Hook.) Benth. suspected.

21. *Satyrium californica* Edwards. California Hairstreak.

Frequent and apparently breeding along the American and Sacramento Rivers, in relict stands of Valley Oak. Otherwise unrecorded except as strays along the edges of the Valley. Sacramento specimens are slightly smaller and darker than foothill ones. One brood. *Host Plant*: Fagaceae: *Quercus lobata* Nee. strongly suspected; no other likely host occurs in the river bottoms.

22. *Satyrium sylvinus* Boisduval. Willow Hairstreak.

Extremely abundant among young gray willows on floodplains and along sloughs and levees; less common in mature riparian forest; rare or absent

elsewhere. Variable in the spotting of the lower wing surfaces and in the extent of orange above. Apparently always fully tailed. *Host Plant*: Salicaceae: *Salix hindsiana* Benth., the common sandbar willow.

23. *Satyrium auretorum* Boisduval. Gold-Hunter's Hairstreak.

Six males and one female taken on the Sacramento River at Elkhorn Ferry, v.12.73 in mixed riparian forest on horehound flowers. These specimens are not phenotypically distinguishable from Vaca Mountains individuals.

24. *Incisalia iroides* Boisduval. Western Brown Elfin.

Occasional in riparian forest and as a stray down the creeks from the foothills. Not known to breed in the Valley, and none of the recorded hosts is present in spring in the riparian forest, but up to 6 have been taken in one day. (Note: The Bramble Hairstreak, *Callophrys dumetorum* Boisduval, is common in the foothills on both sides of the Valley but is unrecorded on the Valley floor although both Polygonaceae: *Eriogonum* and Leguminosae: *Lotus scoparius* (Nutt.) Ottley occur there.)

25. *Lycæna xanthoides* Boisduval. Great Copper.

Common to locally abundant along sloughs and ditches, in marshes and bottomlands, even in alkali marshes. Occasional on roadsides and in agricultural land. One brood in late spring. Females variable, with heavy to light spotting and much to little yellow flush above. *Host Plants*: Polygonaceae: *Rumex crispus* L., *R. conglomeratus* Murr., probably other *Rumex*.

26. *Lycæna helloides* Boisduval. Purplish Copper.

Abundant throughout: damp places, marshes, sloughs, ditches, alkali lands, dry waste ground with compacted clay soils, etc. Five broods, all season. Variable, especially the females; an albino female at Putah Creek, iv.17.72. *Host Plants*: Polygonaceae: *Polygonum aviculare* L. (dry places); *P. lapathifolium* L., *P. persicaria* L., *P. punctatum* Ell., *Rumex crispus* L. (all in wet places).

27. *Hemiargus isola* Reakirt. Reakirt's Blue.

Locally frequent to common, multiple brooded, waste ground near the American River. *Host Plants*: Leguminosae: *Melilotus alba* Desr.; *Medicago sativa* L.

28. *Leptotes marina* Reakirt. Marine Blue.

Locally common to abundant, multiple brooded, railroad and highway embankments and thickets near the American River, and occasional elsewhere. Perhaps not a permanent resident; much commoner in 1973 than 1972. *Host Plants*: Leguminosae: *Glycyrrhiza lepidota* Pursh.; perhaps also *Melilotus alba* Desr.

29. *Brephidium exilis* Boisduval. Western Pygmy Blue.

Extremely abundant on alkaline soils and in alkaline or saline marshes; common to abundant on waste ground with the hosts; occasional elsewhere. Probably does not overwinter in most or all of the Valley, but this needs to be confirmed. About four broods beginning in early summer, commonest after mid-August. *Host Plants*: Chenopodiaceae: *Atriplex hastata* (L.) Hall. & Clem.; *A. rosea* L.; *A. serenana* A. Nels.; *A. coronata* Wats.; *A. cordulata* Jeps.; *A. semibaccata* R. Br.; *Suaeda fruticosa* (L.) Forsk.; *Salsola kali* L. var. *tenuifolia* Tausch.; probably other Chenopods.

30. *Everes comyntas* Godart. Eastern Tailed Blue.

Common along ditches and sloughs and in bottomlands; occasional in moist waste ground and lawns. Five broods; the first with females strongly, the last with them more or less blue-tinted. The Sacramento Valley populations seem phenotypically distinct from others, so it is unlikely that they represent an introduction as has been suggested. *Host Plants*: Leguminosae: *Lotus purshianus* (Benth.) Clem. & Clem.; *Vicia villosa* Roth; *V. sativa* L.; *V. cracca* L.; *V. angustifolia* Reich.; *Lathyrus jepsonii* Greene ssp. *californicus* (Wats.) Hitchc.; *Trifolium tridentatum* Lindl.; *Lupinus nanus* Dougl. ssp. *latifolius* (Benth.) D. Dunn.

31. *Plebeius acmon* Westwood and Hewitson. Acmon Blue.

Common to locally abundant; waste ground, ditches, roadsides, levees,

creek bottoms; occasional everywhere. Five broods, the first of form *cottlei* Grinnell with blue females, the last with transitional males and largely black females. *Host Plants*: Leguminosae: *Lotus purshianus* (Benth.) Clem. & Clem.; *L. scoparius* (Nutt.) Ottley; *Melilotus alba* Desr.; Polygonaceae: *Polygonum aviculare* L.; *Eriogonum gracillimum* Wats. (sandbars, Broderrick).

32. *Plebeius icarioides* Boisduval. Boisduval's Blue.

A single, very worn male, West Sacramento, v.5.73, almost certainly a stray, but too battered to be determined to subspecies.

33. *Glaucopsyche lygdamus behrii* Edwards. Behr's Silvery Blue.

Locally abundant with *Lathyrus jepsonii* along the rivers; infrequent to common in creek bottoms and levee thickets throughout the Valley. Not seen elsewhere. *Host Plants*: *Lathyrus jepsonii* Greene ssp. *californicus* (Wats.) Hitchc. In the Vacas also recorded on *Vicia sativa* L., *V. villosa* Roth, and *Lupinus succulentus* Dougl., all of which also occur in the Valley.

34. *Lycaenopsis argiolus echo* Edwards. Echo Blue.

Infrequent in the American River bottomlands; entering the Valley elsewhere as a stray from the foothills. Breeding not established; the recorded host plants (Hippocastanaceae: *Aesculus*; Ericaceae: *Arctostaphylos*) are generally absent in the Valley.

Family Papilionidae

35. *Battus philenor* Linnaeus. Pipevine Swallowtail.

Frequent to locally common along the creeks near the host plant; occasional in mature riparian forest, and straying widely. One brood at Putah Creek, but perhaps partially four-brooded in Carmichael. *Host Plant*: Aristolochiaceae: *Aristolochia californica* Torr. Sometimes shows a "false brood" in very late fall or very early spring.

36. *Papilio zelicaon* Lucas. Anise Swallowtail.

Frequent to locally abundant on sandy floodplains as at Southport, West Sacramento, and at the American River; occasional throughout. *Host Plant*: Umbelliferae: *Foeniculum vulgare* Mill. Curiously unrecorded from other common Umbellifers, such as *Daucus pusillus* Michx.

37. *Papilio rutulus* Lucas. Western Tiger Swallowtail.

Common in riparian forest, orchards, and older city neighborhoods; occasional throughout. Three broods. *Host Plants*: Oleaceae: *Fraxinus* spp. (larvae, Davis); *Syringa vulgaris* L. (ova, Davis vii.27.73); Rosaceae; *Prunus caroliniana* Ait. (larva, Sacramento). Probably other trees (*Populus*? *Salix*? *Platanus*? other *Prunus*?)

38. *Papilio multicaudatus* Kirby. Two-tailed Swallowtail.

Frequent in riparian forest; apparently two-brooded. Host unrecorded; ash (Oleaceae: *Fraxinus latifolia* Benth.) or *Prunus* spp. (Rosaceae) suspected.

Family Pieridae

39. *Pieris rapae* Linnaeus. European Cabbage Butterfly.

Abundant everywhere; six broods, flying 42 weeks in 1972 and 49 weeks in 1973. The spring brood is heavily dusted beneath, with reduced dark markings above. A mosaic gynandromorph taken at Davis, iii.3.72, and another bred, iv.22.72. *Host Plants*: Cruciferae: *Brassica nigra* (L.) Koch.; *B. kaber* (DC.) Wheeler, *B. oleracea* L. cultivars., *B. geniculata* (Desf.) J. Ball.; *Cardaria draba* (L.) Desv.; *Sisymbrium officinale* (L.) Scop.; *S. irio* L.; *S. altissimum* L.; *Raphanus sativus* L.; *Lepidium latifolium* L.

40. *Pieris protodice* Boisduval and LeConte. Checkered White.

Common to locally abundant on sandy soils, especially on the American River floodplain; generally rare in clay areas, most widespread in viii-x. Not overwintering in most of the Valley, but colonizing widely in summer. Five or six broods, the first of form *vernalis* Edwards, the last transitional to it. The early spring brood is very local but may be common where it does occur. *Host Plants*: Cruciferae: *Brassica geniculata* (Desf.) J. Ball and *Lepidium latifolium* L. preferred; rarely on *Brassica nigra* (L.) Koch.,

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